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The Effect of Aerobic Exercise on Bone Mineral Density and Bone Mineral Content in Female Athlete Patients Following Kidney Transplantation in Shiraz, Southern Iran

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Abstract: Previous researchers indicated the positive influence of physical activities on osteoporosis. This study determined the influence of aerobic exercise on bone mineral density (BMD) in female kidney transplant recipient runners in Southern Iran. From July to October 2010, nine female patients who had a previous history of participation in athletic events for at least 3 years and kidney transplantation were enrolled. They underwent training program for aerobic exercises 3 sessions per week for 8 weeks. Nine non-athletes with a history of kidney transplantation who voluntarily participated in this study were considered as control. All patients received immunosuppressive drugs. Body mass index (BMI) and the serum levels of alkaline phosphatase, calcium and phosphorus were determined for both groups. BMD and bone mineral content (BMC) were determined in femoral neck, trochanter and total femoral bones by x-ray absorptionometry using DPX-MD device. There was no significant difference between the two groups regarding BMI, calcium, phosphorus and alkaline phosphatase serum levels. A significant increase was noticed for BMD in femoral neck, trochanter and femur bones between the two groups but for BMC, the difference was not significant. For lumbar vertebrae, regarding BMD and BMC, the difference was not statistically significant. No osteopenia was visible among both groups. Although kidney transplantation negatively influenced bone mass, but it was shown that participation in physical exercise in kidney transplant patients would prevent side effects of transplantation. Our findings showed that aerobic exercise was beneficial to increase the BMD and BMC in kidney transplant patients.

Key words: Kidney Transplant · Aerobic Exercise · Bone Mineral Density · Iran

INTRODUCTION

Osteoporosis is still a serious health problem worldwide influencing the quality of life and imposing social and financial problems associated with considerable morbidity [1]. Osteoporosis is characterized by low bone mineral density (BMD) resulting into an increased risk of fracture [2]. Fractures caused by osteoporosis can be induced by both internal [e.g., genes and hormones] and external [e.g., life style] factors [3].

Some diseases can influence bone metabolism and as a result on BMD and bone mineral content (BMC). End-stage renal disease patients can be liable to osteoporosis due to low dietary calcium intake, reduced exercise, heparin therapy, low body weight, amenorrhea, premature menopause and renal osteodystrophy [4]. Transplantation is the treatment of choice for end-stage renal disease patients and can relieve many symptoms related to the disease [5]. Lumbar spine and hip bone are mostly affected during the first 3 to 18 months after renal transplantation (4-9 and 5-9%, respectively) [6-8]. It was demonstrated that BMD remains low up to 20 years after transplantation [9].

Exercise may have positive effects on bone density in young adult women preventing osteoporosis [10].

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Different types of sports were shown to have various effects on BMD. Gymnastic [11], tennis [12], soccer and running [13] could significantly increase the BMD in lumbar spine and femur bones among young female athletes. Such an increase in BMD is not seen in lumbar spine bone among swimmers [14]. A positive correlation is noticed between exercise and BMD in healthy people [15] and also among end stage renal disease patients [16] even renal transplant patients are at risk of osteoporosis due to low dietary calcium intake, reduced exercise and heparin therapy [17, 18]. So this study was undertaken to determine the influence of physical exercise on bone mineral density and bone mineral content in female renal patient athletes following renal transplantation in Shiraz, Southern Iran.

MATERIALS AND METHODS

From July to October 2010, nine female athlete patients who had a previous history of participation in athletic events for at least 3 years and kidney transplantation (age: 25±3.4 years, weight: 53.5±7.09 kg, height: 159.83±4.6 cm) were enrolled. They underwent training program for aerobic exercises 3 sessions per week for 8 weeks. The intense of the training program proceeded from 50 to 55% in the first 2 weeks, 55to 60% in the second 2 weeks, 60 to 65% in the third 2 weeks and 65 to 70% of maximum heart beat in the last 2 weeks. The duration of training programs without the warm up and cool-down was 15 minutes (balk field test) [13]. The intense training program was controlled and regulated using a polar. All subjects performed a warm up (20 minutes) and a cool-down (15 minutes) program in every training session. Nine other non-athlete female patients with a previous history of kidney transplantation (Age: 27.55±2.24 years, weight: 61.88±22.51 kg, height: 154.55±4.82 cm) who voluntarily participated in this study were considered as the control group. All patients received immunosuppressive drugs such as prednisolone and cyclosporine. Body mass index (BMI) and the serum levels of alkaline phosphatase, calcium and phosphorus were determined for both groups. The exclusion criteria were smoking, receiving levothyroxine and kidney transplantation for the second or third time. The subjects fulfilled a written consent form for participation in this study. The study was approved in the Ethics Committee of Shiraz University.

BMD (g/cm^2) and BMC (g) at the lumbar spine (first to fourth lumbar vertebrae), femur (neck, trochanter and the whole femur) were measured by dual x-ray absorptiometry using DEXA densitometer (HOLOGIC).

SPSS software (version 16, Chicago, IL, USA) was used for statistical analysis. Unpaired t test was used to compare variables. T score (comparison with the mean bone density in adults) with reference to the World Health Organization and Z score were used for comparison. A p value of less than 0.05 was considered statistically significant.

RESULTS

Participants' characteristics were presented in table 1. There was no significant difference between the athletic and non-athletic groups regarding BMI, calcium, phosphorus and alkaline phosphatase serum levels. A significant increase was noticed for BMD in femoral neck, trochanter and the femur bones between the two groups but for BMC, the difference was not significant between the two groups. For lumbar vertebrae, regarding BMD and BMC, the difference was not statistically significant. No osteopenia was visible among both groups (Table 2).

Table 1: Characteristics of participants (mean±SD)

Characteristic	Athletes n=9	Non athletes n=9	P-Value
Age (year)	25±3.74	27.55±2.24	0.12
Weight (kg)	53.50±7.09	61.88±22	0.39
Height (m)	1.59±4.6	1.54±4.8	0.05*
Body mass index (kg/m^2)	21±1.8	26±8.6	0.19
Month since transplantation	39.2±2	40±3.5	0.35
Serum alkaline phosphate (mg/dL)	1.58±36.57	1.45±32.81	0.46
Serum calcium (mg/dL)	9.15±0.75	9.61±0.16	0.09
Serum phosphorus (mg/dL)	3.95±0.51	4.24±0.72	0.35
Cumulate prednisolon (g)	7.34±3.43	8.12±0.11	0.43
Cumulative cyclosporine (g)	169.28±110.64	175.0±98.43	0.29

*Significant difference

Table 2: Comparison of BMD and BMC in athletic and non-athletic kidney transplant patients.

Variable		Athletes (Mean±SD)	Non athletes (Mean±SD)	Sig. (2-tailed)
Lumbar vertebrae				
-	BMD	0.92±0.045	0.90±0.045	0.53
-	BMC	51.47±7.68	45.63±6.58	0.13
-	T score	-1.06±0.40	-1.27±0.74	0.53
-	Z score	-0.93±0.30	-0.92±0.74	0.97
Femur neck				
-	BMD	0.75±0.06	0.67±0.09	0.05*
-	BMC	3.61±0.42	3.1±0.51	0.03*
-	T score	-0.80±0.54	-1.56±0.87	0.05*
-	Z score	-0.76±0.57	-1.41±0.90	0.14
Femur trochanter				
-	BMD	0.64±0.04	0.58±0.06	0.05*
-	BMC	6.05±1.47	5.25±0.72	0.12
-	T score	-0.58±0.46	-1.17±0.68	0.05*
-	Z score	-0.56±0.51	-1.12±0.71	0.11
Total femur				
-	BMD	0.87±0.05	0.79±0.06	0.03*
-	BMC	26.71±4.42	22.93±2.69	0.05*
-	T score	-0.58±0.44	-1.16±0.5	0.04*
-	Z score	-0.58±0.49	-1.07±0.56	0.01*

*Significant difference

DISCUSSION

The regulation of osteoclastic activity is of great importance to understand bone changes induced by exercise (mechanical load) [19]. Moreover, the findings are discordant, depending on the type, duration of exercise, intensity and on participants' age and functional status [19].

The mechanical loading of bone through exercise was determined thoroughly due to its potential to positively change the structural variables such as bone mass [20].These changes in bony tissue after exercises was shown to be due to strain (defined as the fractional change in the dimension of a bone in response to a changing load) [21], which demonstrates the key intermediate variable and to its influence on cells by directly altering their dimensions or indirectly affecting shear stresses, intralacunar pressure, or charged fluid flow [22]. In the present study, the aerobic exercise based intervention could significantly increase femoral BMD and BMC in athletic patients but for the vertebral bone mass which BMD and BMC was higher in athletic group, the difference was not statistically significant. Some studies showed the positive influence of physical activities on BMD and BMC in non-transplant individuals [11-13]. A higher BMD in lumbar bone mass was reported in men and women who had been a distance runner for nine years compared with sedentary subjects [23]. Running and many other weight bearing exercises such as volleyball and basketball had significantly indicated increasing bone mass in calcaneus, femoral shaft, head of humerous and distal forearm bones [15]. In addition, previous studies using aerobic training protocols revealed conflicting results regarding BMD. Although Silverman *et al*. [24] noticed a significant improvement of 2% at the femoral neck in postmenopausal women after a 24-week walking program. Indeed, Kohrt *et al*. [25] findings denoted that an exercise program including walking, jogging and stair climbing lead to significant increases in BMD of the whole body, lumbar spine, femoral neck and Ward's triangle. Conversely, our findings suggested that the aerobic exercise lead to an increase in BMD and BMC in patients undergoing kidney transplant.

Many mechanisms are involved in bone loss in kidney transplant patients including calcitriol deficiency, hypocalcemia, hyperphosphatemia and a rapid decline in the high level of PTH and they may never completely be normalized. PTH-dependent hypercalcemia and hypophosphatemia may develop during a short time period after kidney transplantation [26]. Researchers have indicated that physical exercise increases parathyroid hormone [27]. In our study, no symptoms according to

PTH insufficiency were observed in any of participants and there were no significant differences in bone metabolism markers (phosphate and calcium ions and alkaline phosphate) between the two groups (Table 1).

Bone mechano-sensors are also very important for the integrity of the skeleton, because in response to mechanical load, bone modeling is activated, which cause increasing of bone density and strength. Muscle contractions result in a larger physiological load [3] and probably it is one of the major mechanisms which prevent the effect of immunosuppressant drugs on bone loss. However, future researches which prospectively assess the effect of transplantation are recommended.

A major limitation of our study was small number of participants. A prospective study with larger number of participants seems necessary. Although kidney transplantation negatively influenced bone mass, but it was shown that participation in physical exercise in kidney transplant patients would prevent side effects of transplantation. Our findings showed that aerobic exercise was beneficial to increase the BMD and BMC in kidney transplant patients.

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